

Chapter 7

Evaluating Trade-off Issues

This chapter serves to summarize much of the information presented throughout the CTSA. Section 7.1 presents a summary of the findings, drawing upon the risk information developed in Chapter 3 and the cost analysis developed in Chapter 4. Section 7.2 presents a benefit/cost analysis of using the baseline blanket wash, VM&P naphtha, compared to the substitute blanket washes. Information on costs, exposures and risks are presented here so that an easy comparison can be made between the substitute blanket washes and the baseline.

Section 7.3 provides summary sheets for each blanket wash. These summary sheets contain information on composition, performance, cost, risk, exposure, and regulatory concerns and are intended to provide the reader with a quick reference guide for each blanket wash.

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7.1 FINDINGS

Earlier sections of the CTSA evaluated the risk and performance of the baseline blanket wash as well as the alternatives. This section presents the findings associated with the analysis of blanket washes. Relevant data include: worker health risks, public health risks, flammability risks, ecological risk, energy and natural resource use, VOC content, and labor, materials, and product costs. Each is discussed in turn below.

Worker Health Risks

The majority of substitute formulations, as well as the baseline, present some concern for dermal exposure, driven primarily by high exposure levels estimated in Chapter 3. The dermal exposure estimates provide an upper-bound estimate which no worker is expected to exceed because the exposure assessment assumes that no gloves or barrier creams are used by workers when cleaning a blanket. Worker inhalation risks are very low for nearly all of the blanket wash products due to low or negligible exposure levels. Only one of the substitute formulations (Blanket Wash 3) triggered inhalation concerns. The components of all other substitute products present low or no concern. The baseline presents low inhalation concern. Table 7-1 presents a summary of worker risks beginning with the baseline product, VM&P naphtha. The risk assessment assumed that components of concern present a greater risk than components of low to moderate concern, and components of low to moderate present a greater risk than components of low concern, and so on (no/low concern < low to moderate concern < concern).

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Table 7-1. Summary of Risk Conclusions of Substitute and Baseline Blanket Wash Cleaners

Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
Baseline (28)	Hydrocarbons, petroleum distillates	concern	no/low concern
1	No individual chemicals of concern identified	no/low concern ¹	no/low concern ¹
3	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, aromatic	concern	concern
	Hydrocarbons, aromatic	concern	no/low concern
4	Terpenes	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
5	Hydrocarbons, aromatic	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
	Ethylene glycol ethers	concern	no/low concern
6	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
	Fatty acid derivatives	no/low concern ²	no/low concern ²
	Alkyl benzene sulfonates	no/low concern ²	no/low concern ²
7	Terpenes	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
8	Propylene glycol ethers	no/low concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
9	Ethoxylated nonylphenol	no/low concern	no/low concern ²
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
10	Fatty acid derivatives	no/low concern ¹	no/low concern ²
11	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
	Alkyl benzene sulfonates	no/low concern ¹	no/low concern ²
12	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹
14	Fatty acid derivatives	no/low concern ¹	no/low concern ²
	Propylene glycol ethers	no/low concern ¹	no/low concern ¹
16	Terpenes	concern	no/low concern

Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
17	Glycols	no/low concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
	Alkali/salts	no/low concern	no/low concern ²
	Fatty acid derivatives	possible concern	no/low concern ²
18	Hydrocarbons, petroleum distillates	concern	no/low concern
	Dibasic esters	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern ¹	no/low concern ¹
	Esters/lactones	no/low concern ¹	no/low concern ¹
19	Propylene glycol ethers	no/low concern ¹	no/low concern ¹
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
20	Hydrocarbons, petroleum distillates	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern ¹	no/low concern ¹
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ¹
21	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Fatty acid derivatives	no/low concern ¹	no/low concern ¹
22	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
23	Terpenes	possible concern	no/low concern
	Nitrogen heterocyclics	possible concern	no/low concern
24	Alkyl benzene sulfonates	concern	no/low concern ²
	Terpenes	concern	no/low concern
	Ethylene glycol ethers	possible concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
25	Terpenes	concern	no/low concern
	Esters/lactones	possible concern	no/low concern
26	Esters/lactones	concern	no/low concern ²
	Esters/lactones	no/low concern	no/low concern ²
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
27	Terpenes	concern	no/low concern
29	Fatty acid derivatives	no/low concern ¹	no/low concern ²
30	Hydrocarbons, aromatic	concern	no/low concern
	Propylene glycol ethers	no/low concern ¹	no/low concern ¹
31	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹

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Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
32	Hydrocarbons, petroleum distillates	low to moderate concern ¹	low to moderate concern ¹
33	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	no/low concern	no/low concern
34	Terpenes	concern	no/low concern
	Alkoxylated alcohols	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹
35	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹
36	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
	Propylene glycol ethers	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern ¹	no/low concern ²
37	Hydrocarbons, aromatic	possible concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹
	Hydrocarbons, petroleum distillates	low to moderate concern ¹	no/low concern ¹
38	Fatty acid derivatives	no/low concern ¹	no/low concern ²
	Alkoxylated alcohols	no/low concern ¹	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern	no/low concern ¹
39	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	no/low concern	no/low concern
	Alkanolamines	concern	no/low concern ²
	Ethylene glycol ethers	possible concerns	no/low concern
40	Hydrocarbons, petroleum distillates	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ²
	Hydrocarbons, aromatic	moderate concern ¹	no/low concern ²
	Fatty acid derivatives	no/low concern ¹	no/low concern ²

¹ Risks for this chemical in this product could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis of potential hazard.

² Risks for this chemical in this product could not be quantified; therefore, the level of concern for this chemical is based upon a low risk call based on estimates of no or extremely low exposure.

Public Health Risk

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Individuals in the general public that are exposed to blanket wash chemicals are potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion due to use of blanket washes under the small shop scenario used here. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.^a Flammable liquids are defined by OSHA as having a flash point less than 141°F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140°F or less. Table 7-2 presents the flash points of the baseline as well as the alternative blanket washes. Flash points were developed as part of the performance demonstration.

Table 7-2. Relative Flammability Risk of Substitute and Baseline Blanket Washes

Blanket Wash	Flash Point (°F)	Blanket Wash	Flash Point (°F)
<i>Baseline (28)</i>	50	22	157+
1	230+	23	140
3	114	24	100
4	114	25	220+
5	139	26	230+
6	152	27	145
7	165	29	230+
8	115	30	100+
9	230+	31	105
10	230+	32	220
11	150	33	105
12	125	34	138
14	230+	35	105
16	145	36	175

^aFlash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

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Blanket Wash	Flash Point (°F)	Blanket Wash	Flash Point (°F)
17	220+	37	82
18	150	38	230+
19	230+	39	155
20	170	40	155
21	115		

Ecological Risk

The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; in the analysis for this CTSA, only the risks to aquatic species were considered. Evaluation of aquatic risks involved comparing a predicted ambient water concentration to a “concern concentration” for chronic exposures to aquatic species using a hypothetical receiving stream (a relatively small stream at low flow conditions). The concern concentration is expressed in mg/L water. Exposure concentrations below the concern concentration are assumed to present low risk to aquatic species. Exposures that exceed the concern concentration indicate a potential for adverse impact on aquatic species. Two chemicals contained in the blanket wash formulations may present risks to aquatic organisms. The two chemicals were alkyl benzene sulfonates, present in Formulations 3, 4, 6, 8, 11, 18, and 20, and ethoxylated nonylphenols, present in Formulations 4, 5, 7, 8, 9, 17, 24, and 40. Risks to plants (other than aquatic algae) and wildlife were not examined. Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Use

As described in Chapter 5, the life cycle of any product begins with the extraction of raw materials from the environment, and continues through the manufacture, transportation, use, recycle, and disposal of the product. Decisions at each stage of a product’s life will impact its energy and natural resource demand. Section 5.1, Energy and Natural Resource Issues, presents a discussion describing the issues to consider when cleaning the blanket and purchasing blanket washes but does not analyze the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. The issues discussed include: 1) optimization of the washing technique to reduce blanket wash use, press wipe use, and waste print runs; 2) derivation of blanket wash products from non-renewable (petroleum and natural gas) and renewable (plant products) chemical raw materials (it is not clear, however, which raw materials demand the least energy and natural resources without a full life-cycle analysis); 3) lack of differentiation between products in terms of energy consumption during the product formulation process because the same basic processes are used to formulate all blanket wash products; and 4) reduction in packaging requirements and transportation/distribution energy consumption due to the use of concentrated formulations, assuming the products are diluted by the printer. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

Volatile Organic Compound (VOC) Releases

As described in Chapter 4, the volatile organic compound (VOC) content of the alternative and the baseline blanket washes was independently tested by the GATF laboratory

in Pittsburgh, Pennsylvania. VOCs are currently regulated under clean air legislation occupational exposure rules and toxics use and release reporting laws; therefore, substitution of high VOC cleaners has the potential to reduce the regulatory burden for printers. Table 7-3 presents a summary of the relative VOC content of the baseline and alternative blanket washes.

Table 7-3. VOC Content of the Substitute and Baseline Blanket Washes

Blanket Wash	VOC Content (lbs/gal;% by weight)	Blanket Wash	VOC Content (lbs/gal;% by weight)
Baseline (28)	6.2; 100%	22	Not measured; 2.17%
1	2.3; 30%	23	0.48; 6%
3	6.4; 91%	24	1.5; 19%
4	6.4; 89%	25	4.1; 55%
5	2.5; 30%	26	1.3; 18%
6	3.5; 47%	27	7.2; 93%
7	3.0; 36%	29	2.1; 30%
8	3.3; 41%	30	0.48; 7%
9	0.11; 10%	31	6.6; 99%
10	0.16; 2%	32	6.5; 99%
11	4.3; 61%	33	3.4; 46%
12	1.3; 20%	34	2.8; 39%
14	0.97; 12%	35	6.7; 99%
16	7.2; 99%	36	3.5; 48%
17	0.051; 0.6%	37	1.0; 14%
18	4.4; 60%	38	4.9; 65%
19	1.8; 22%	39	2.9; 37%
20	2.7; 35%	40	3.8; 52%
21	3.5; 47%		

Performance

The performance of each of the substitute blanket washes as well as the baseline was demonstrated using both laboratory and production run tests. The laboratory tests determined the flash point, VOC content, and pH and demonstrated the blanket swell and wipability of each product. The production run tests, conducted at two facilities for each of the substitute products and at all facilities for the baseline, collected information such as quantity of wash

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used, time spent to wash the blanket, ink coverage, and the effectiveness of the wash. Summary results are presented in Table 7-4. The widely variable conditions between and within printing facilities and the short duration of the production runs used for the performance demonstrations does not allow the results to be interpreted as definitive performance assessments of the blanket washes.

Table 7-4. Blanket Wash Laboratory Test Results

Form. No.	Flash Point (°F)	VOC Content ¹ (lbs/gal; % by weight)	pH	Blanket Swell		Wet Ink Film Strokes	Dry Ink Film Strokes
				1 hr (%)	5 hr (%)		
1	230+	2.3; 30%	7.8*	1.5	3.0	4	6
3	114	6.4; 91%	3.4*	1.5	4.5	4	4
4	114	6.4; 89%	8.7	3.0	5.2	3	2
5	139	2.5; 30%	4.3	6.1	15.4	9	8
6	152	3.5; 47%	5.5	0.7	1.5	8	6
7	165	3.0; 36%	9.3	3.8	6.8	6	8
8	115	3.3; 41%	4.0	7.7	20	7	9
9	230+	0.77; 10%	4.6	1.5	1.5	19	30
10	230+	0.16; 2%	5.7	0.7	0.7	12	13
11	150	4.3; 61%	5.0*	0.0	1.5	4	5
12	125	1.3; 20%	8.2	0.0	1.5	7	11
14	230+	0.97; 12%	5.0	1.5	3.0	8	10
16	145	7.2; 99%	9.8	4.5	10.6	2	2
17	220+	0.051; 0.6%	9.8	1.5	1.5	100	100
18	150	4.4; 60%	5.5	1.5	4.5	8	7
19	230+	1.8; 22%	4.6	1.5	1.5	11	9
20	170	2.7; 35%	7.1	0.0	1.5	5	7
21	115	3.5; 47%	6.2	0.0	1.5	7	6
22	157(a)	NM; 2.17% ²	7.4(c)	1.5	1.5	13	13
23	140	0.48; 6%	9.2	0.0	1.5	24	100
24	100	1.5; 19%	9.9	1.5	3.0	15	12
25	220+	4.1; 55%	4.3	3.0	4.5	22	32
26	230+	1.3; 18%	7.8*	0.0	0.0	6	14
27	145	7.2; 93%	3.9	3.0	4.5	3	3
28	50	6.2; 100%	6.6	1.5	3.0	3	8
29	230+	2.1; 30%	7.2	1.5	1.5	9	18
30	100(a)	0.48; 7%	7.6(c)	0.7	1.5	5	11

Form. No.	Flash Point (°F)	VOC Content ¹ (lbs/gal; % by weight)	pH	Blanket Swell		Wet Ink Film Strokes	Dry Ink Film Strokes
				1 hr (%)	5 hr (%)		
31	105	6.6; 99%	7.6	1.5	3.0	3	3
32	220	6.5; 99%	8.5	0.1	1.5	5	30
33	105	3.4; 46%	7.2*	4.5	7.6	4	4
34	138	2.8; 39%	6.6	1.5	3.0	10	20
35	105	6.7; 99%	6.0	1.5	6.1	3	5
36	175	3.5; 48%	5.7*	0.7	1.5	4	5
37	82	1.0; 14%	3.9	3.0	3.0	5	8
38	230+	4.9; 65%	5.6	0.0	1.5	9	16
39	155	2.9; 37%	9.2	1.5	3.0	7	10
40	155	3.8; 52%	4.8	1.5	3.0	5	10
(a) full strength (c) 25% NC - not calculated NM - not measured * - pH fluctuates wildly							

¹VOC content in lbs/gal was measured at GATF; % by weight VOC was calculated based on information submitted by the manufacturer.

²VOC content in lbs/gal was not measurable; % by weight VOC was submitted by the manufacturer.

Prior to testing the blanket washes in a print shop, the 36 substitute blanket washes were tested in the laboratory for blanket swell potential and wipability. Of the 36 washes, 22 were deemed to be satisfactory for demonstrations at volunteer printing shops (two shops demonstrated each blanket wash). The results of the performance demonstrations were highly variable between the two print shops using a particular blanket wash and among the many blanket washes themselves. Performance varied to a great extent based on the amount of ink coverage. Excluding trials with heavy ink coverage, eleven washes gave good or fair performances at both facilities, seven washes gave good or fair performance at one facility but not the other, and the remaining four washes performed poorly at both facilities.

Labor, Materials, and Product Costs

The costs of using each of the substitute blanket washes as well as the baseline depend on variations in labor costs, product use, and material and equipment use at each facility that participated in the performance demonstrations. Each substitute blanket wash product was tested by two facilities. The baseline product was tested by all facilities. Costs for each product are presented on a per wash basis, a per press basis, and a cost per press/shift/year basis. In comparing the cost data for the substitute and the baseline products, the costs of using the substitute blanket cleaners exceed the cost of using the baseline product in nearly all cases. In some cases smaller quantities of wash or less cleaning time was required, resulting in a cost savings when using the substitute instead of the baseline wash. Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs associated with using the substitute blanket washes range from a low

of \$1.72 to a high of \$8.80 per press.^b Costs of using the baseline product range from \$1.64 to \$3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from one percent to 179 percent. Table 7-5 presents a summary of the cost comparisons.

Disposal costs were not considered in this cost comparison because all but one of the printers participating in the performance demonstrations use cloth wipes that are leased from an industrial laundry. Many industrial laundries currently do not distinguish between hazardous and nonhazardous blanket washes when laundering wipes; therefore, it was assumed that there would be no savings in waste handling or processing costs associated with switching to a substitute blanket wash product.

7.2 QUALITATIVE DISCUSSION OF BENEFIT/COST ANALYSIS

7.2.1 Introduction

Social benefit/cost analysis is a tool used by policy makers to systematically evaluate the impacts to all of *society* resulting from individual decisions. The decision evaluated in this analysis is the choice of a blanket wash product. Printers have certain criteria which they use to evaluate the benefits and costs of alternative blanket cleaners such as price, drying time, flexibility of use for rollers and blankets, propensity to cause blanket swell, etc. A printer might ask what impact their choice of blanket washes will have on operating costs, compliance costs, liability costs, and insurance premiums. This business planning process is unlike social benefit/cost analysis, however, because it approaches the comparison from the standpoint of the individual printing firm and not from the standpoint of *society*. A social benefit/cost analysis seeks to compare the benefits and costs of a given action, considering both the private and external costs and benefits.^c Therefore, the analysis will consider the impact of the alternative blanket cleaners on operating costs, regulatory costs, and insurance premiums, but will also consider the *external* costs and benefits of the alternative blanket cleaners such as reductions in environmental damage and reductions in the risk of illness for the general public. External costs are not borne by the printer, however; they are true costs to society.

Benefits of the substitute blanket cleaners may include private benefits such as increased profits resulting from improved worker productivity, a reduction in employee sickness, or reduced property and health insurance costs and external benefits such as a reduction in pollutants emitted to the environment or reduced use of natural resources. Costs of the substitute blanket cleaners may include private costs such as higher operating expenses resulting from a higher priced blanket wash and external costs such as an increase in human health risks and ecological damage. Several of the benefit categories considered in this analysis share elements of both private and external costs and benefits. For example, use of the substitute blanket washes may result in energy and natural resource savings. Such a

^b Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.

^c Private costs include any direct costs incurred by the decision-maker and are typically reflected in the firm's balance sheet. In contrast, external costs are incurred by parties other than the primary participants to the transaction. Economists distinguish between private and external costs because each will affect the decision maker differently. Although external costs are real costs to some members of society, they are not incurred by the decision maker and firms do not normally take them into account when making their decisions. A common example of external costs is the electric utility whose emissions are reducing crop yields for the farmer operating downwind. The external costs incurred by the farmer in the form of reduced crop yields are not considered by the utility when deciding how much electricity to produce. The farmer's losses do not appear on the utility's balance sheet.

Table 7-5. Summary of Cost Analysis for Blanket Wash Performance Demonstration

Formula Number	Test Facility	Total cost/wash (Baseline)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference ¹
1	Facility 3	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 6	0.46	0.87	1.84	3.48	4,600	8,700	+89
6	Facility 11	0.70	0.82	2.80	3.28	7,000	8,200	+17
	Facility 15	0.50	0.77	2.00	3.08	5,000	7,700	+54
9	Facility 10	0.91	2.08	3.64	8.32	9,100	20,800	+129
	Facility 15	0.50	0.92	2.00	3.68	5,000	9,200	+84
10	Facility 3	0.55	0.57	2.20	2.28	5,500	5,700	+4
	Facility 4	0.85	2.20	3.40	8.80	8,500	22,000	+159
11	Facility 1	0.59	1.29	2.36	5.16	5,900	12,900	+119
	Facility 2	0.53	0.68	2.12	2.72	5,300	6,800	+28
12	Facility 12	0.81	0.99	3.24	3.96	8,100	9,900	+22
	Facility 13	0.80	0.83	3.20	3.32	8,000	8,300	+4
14	Facility 6	0.46	1.07	1.84	4.28	4,600	10,700	+133
	Facility 16	0.66	0.82	2.64	3.28	6,600	8,200	+24
19	Facility 18	0.62	1.66	2.48	6.64	6,200	16,600	+168
	Facility 19	0.53	0.89	2.12	3.56	5,300	8,900	+68
20	Facility 11	0.70	1.13	2.80	4.52	7,000	11,300	+61
	Facility 12	0.81	1.58	3.24	6.32	8,100	15,800	+95

¹ A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

Formula Number	Test Facility	Total cost/wash (Base)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference ¹
21	Facility 6	0.46	1.01	1.84	4.04	4,600	10,100	+120
	Facility 17	0.41	0.58	1.64	2.32	4,100	5,800	+41
22	Facility 12	0.81	0.82	3.24	3.28	8,100	8,200	+1
	Facility 13	0.80	1.51	3.20	6.04	8,000	15,100	+89
24	Facility 16	0.66	0.97	2.64	3.88	6,600	9,700	+47
	Facility 17	0.41	0.88	1.64	3.52	4,100	8,800	+115
26	Facility 5	0.55	0.73	2.20	2.92	5,500	7,300	+33
	Facility 15	0.50	0.47	2.00	1.88	5,000	4,700	-6
29	Facility 7	0.57	0.93	2.28	3.72	5,700	9,300	+63
	Facility 8	0.55	0.89	2.20	3.56	5,500	8,900	+62
30	Facility 18	0.62	1.01	2.48	4.04	6,200	10,100	+63
	Facility 19	0.53	0.62	2.12	2.48	5,300	6,200	+17
31	Facility 7	0.57	1.59	2.28	6.36	5,700	15,900	+179
	Facility 8	0.55	0.59	2.20	2.36	5,500	5,900	+7
32	Facility 1	0.59	1.31	2.36	5.24	5,900	13,100	+122
	Facility 5	0.53	0.43	2.12	1.72	5,300	4,300	-19
34	Facility 1	0.59	0.89	2.36	3.56	5,900	8,900	+51
	Facility 19	0.53	0.95	2.12	3.80	5,300	9,500	+79

¹ A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

Formula Number	Test Facility	Total cost/wash (Base)	Total cost/wash (Alternative)	Total cost/press (Base)	Total cost/press (Alternative)	Total cost/press/shift/year (Base)	Total cost/press/shift/year (Alternative)	Percentage Difference ¹
37	Facility 3	0.55	0.48	2.20	1.92	5,500	4,800	-13
	Facility 4	0.85	0.79	3.40	3.16	8,500	7,900	-7
38	Facility 2	0.53	1.08	2.12	4.32	5,300	10,800	+104
	Facility 4	0.85	1.11	3.40	4.44	8,500	11,100	+31
39	Facility 5	0.55	0.69	2.20	2.76	5,500	6,900	+25
	Facility 8	0.55	0.80	2.20	3.20	5,500	8,000	+45
40	Facility 1	0.59	0.79	2.36	3.16	5,900	7,900	+34
	Facility 10	0.91	0.87	3.64	3.48	9,100	8,700	-4

¹ A positive sign denotes an increase and a negative sign denotes a decrease in the cost when using the alternative blanket cleaner instead of the base product.

The following terms are used throughout the benefit/cost analysis:

Table 7-6. Glossary of Benefit/Cost Analysis Terms

<u>Term</u>	<u>Definition</u>
Exposed Population	The estimated number of people from the general public or a specific population group who are exposed to a chemical through wide dispersion of a chemical in the environment (e.g., DDT). A specific population group could be exposed to a chemical due to its physical proximity to a manufacturing facility (e.g., residents who live near a facility using a chemical), use of the chemical or a product containing a chemical, or through other means.
Exposed Worker Population	The estimated number of employees in an industry exposed to the chemical, process and/or technology under consideration. This number may be based on market share data as well as estimations of the number of facilities and the number of employees in each facility associated with the chemical, process, and/or technology under consideration.
Externality	A cost or benefit that involves a third party who is not a part of a market transaction; "a direct effect on another's profit or welfare arising as an incidental by-product of some other person's or firm's legitimate activity" (Mishan, 1976). The term "externality" is a general term which can refer to either <u>external benefits</u> or <u>external costs</u> .
External Benefits	For example, if an educational program results in behavioral changes which reduce the exposure of a population group to a disease, then an external benefit is experienced by those members of the group who did not participate in the educational program. For the example of nonsmokers exposed to second-hand smoke, an external benefit can be said to result when smokers are removed from situations in which they expose nonsmokers to tobacco smoke.
External Costs	For example, if a steel mill emits waste into a river which poisons the fish in a nearby fishery, the fishery experiences an external cost as a consequence of the steel production. Another example of an external cost is the effect of second-hand smoke on nonsmokers.
Human Health Benefits	Reduced health risks to workers in an industry or business as well as to the general public as a result of switching to less toxic or less hazardous chemicals, processes, and/or technologies. An example would be switching to a less volatile organic compound, lessening worker inhalation exposures as well as decreasing the formation of photochemical smog in the ambient air.
Human Health Costs	The cost of adverse human health effects associated with production, consumption, and disposal of a firm's product. An example is respiratory effects from stack emissions, which can be quantified by analyzing the resulting costs of health care and the reduction in life expectancy, as well as the lost wages as a result of being unable to work.
Illness Costs	A financial term referring to the liability and health care insurance costs a company must pay to protect itself against injury or disability to its workers or other affected individuals. These costs are known as illness benefits to the affected individual.

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Indirect Medical Costs	Indirect medical costs associated with a disease or medical condition resulting from exposure to a chemical or product. Examples would be the decreased productivity of patients suffering a disability or death and the value of pain and suffering borne by the afflicted individual and/or family and friends.
Private (Internalized) Costs	The direct costs incurred by industry or consumers in the marketplace. Examples include a firm's cost of raw materials and labor, a firm's costs of complying with environmental regulations, or the cost to a consumer of purchasing a product.
Social Cost	The total cost of an activity that is imposed on society. Social costs are the sum of the private costs and the external costs. Therefore, in the example of the steel mill, social costs of steel production are the sum of all private costs (e.g., raw material and labor costs) and the sum of all external costs (e.g., the costs associated with the poisoned fish).
Social Benefit	The total benefit of an activity that society receives, i.e., the sum of the private benefits and the external benefits. For example, if a new product yields pollution prevention opportunities (e.g., reduced waste in production or consumption of the product), then the total benefit to society of the new product is the sum of the private benefit (value of the product that is reflected in the marketplace) and the external benefit (benefit society receives from reduced waste).
Willingness-to-pay	Estimates used in benefits valuation intended to encompass the full value of avoiding a health or environmental effect. For human health effects, the components of willingness-to-pay include the value of avoiding pain and suffering, impacts on the quality of life, costs of medical treatment, loss of income, and, in the case of mortality, the value of a life.

benefit may result in private benefits in the form of reduced product usage and waste print runs as well as external benefits in the form of reduced consumption of non-renewable resources.

7.2.2 Benefit/Cost Methodology

The methodology for conducting a social benefit/cost assessment can be broken down into four general steps: 1) obtain information on the relative performance, human and environmental risk, process safety hazards, and energy and natural resource requirements of the baseline and the alternatives; 2) construct matrices of the data collected; 3) when possible, monetize the values presented within the matrices; and 4) compare the data generated for the alternative and the baseline in order to produce an estimate of net social benefits. Section 7.1 presents the results of the first task by summarizing the performance data, risk data, and energy and natural resource information for the baseline and the alternative blanket washes. In Table 7.5 the data required to make a determination of the relative costs and benefits of switching to an alternative blanket wash are organized according to formulation number, beginning with the baseline. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products, allowing identification of the substitute product whose use results in the largest net social benefits. However, because of data limitations and production facility variations, the analysis presents instead a qualitative description of the risks associated with each substitute product compared to the baseline. Benefits derived from a reduction in risk are described and discussed, but not quantified; the information provided can be very useful in the decision making process. A few examples are provided to quantitatively illustrate some of the benefit considerations. Personnel in each individual facility will have to examine the information

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presented, weigh each piece according to facility and community characteristics, and develop an independent choice.

The analysis is further developed in the following sections, beginning in Section 7.2.3 with summaries of the potential risks of the substitute and baseline blanket washes. Section 7.2.4 provides a summary of the financial costs of the baseline and the alternative blanket washes, Section 7.2.5 compares the benefits and costs of using the substitute blanket wash products instead of the baseline wash, and Section 7.2.6 provides an indication of the minimum benefits per affected person that would accrue to society if switching to substitute blanket wash products reduced cases of certain adverse health effects.

Table 7-7. Costs and Benefits of Baseline and Substitute Blanket Washes

Formula Number	Private Costs ¹		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk ²	% VOC	Environmental Risk
Baseline (28)			Low to moderate concern for dermal and inhalation exposure. ⁴	High risk	99%	No estimated risk
1	Alternative: 2.76 Baseline: 2.20	+25	Overall concern is low for dermal and inhalation exposure. ⁴	Low risk	30%	No estimated risk
	Alternative: 3.48 Baseline: 1.84	+89				
3	Not tested		Concern for dermal exposure and inhalation exposure.	Moderate Risk	91%	Aquatic species risk
4	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	89%	Aquatic species risk
5	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	30%	Aquatic species risk
6	Alternative: 3.28 Baseline: 2.80	+17	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	47%	Aquatic species risk
	Alternative: 3.08 Baseline: 2.00	+54				
7	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Low Risk	36%	Aquatic species risk
8	Not tested		Low concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	41%	Aquatic species risk

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Formula Number	Private Costs ¹			Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk ²	% VOC	Environmental Risk	
9	Alternative: 8.32 Baseline: 3.64	+129	Very low concern for dermal exposure and no concern for inhalation exposure. ⁴	Low risk	10%	Aquatic species risk	
	Alternative: 3.68 Baseline: 2.00	+84					
10	Alternative: 2.28 Baseline: 2.20	+4	Very low concern for dermal exposure ³ and no concern for inhalation exposure. ⁴	Low risk	2%	No estimated risk	
	Alternative: 8.80 Baseline: 3.40	+159					
11	Alternative: 5.16 Baseline: 2.36	+119	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	61%	Aquatic species risk	
	Alternative: 2.72 Baseline: 2.12	+28					
12	Alternative: 3.96 Baseline: 3.24	+22	Concern for dermal exposure and low concern for inhalation exposure. ³	Moderate risk	20%	No estimated risk	
	Alternative: 3.32 Baseline: 3.20	+4					
14	Alternative: 4.28 Baseline: 1.84	+133	Low concern for dermal and inhalation exposure. ³	Low risk	12%	No estimated risk	
	Alternative: 3.28 Baseline: 2.64	+24					
16	Not tested		Concern for dermal	Moderate	99%	No estimated	
17	Not tested		Possible concern for dermal	Low Risk	0.6%	Aquatic	
19	Alternative: 6.64 Baseline: 2.48	+168	Low concern for dermal and inhalation exposure. ³	Low risk	22%	No estimated risk	
	Alternative: 3.56 Baseline: 2.12	+68					
20	Alternative: 4.52 Baseline: 2.80	+61	Concern for dermal exposure and low concern for inhalation exposure. ³	Low risk	35%	Aquatic species risk	
	Alternative: 6.32 Baseline: 3.24	+95					
21	Alternative: 4.04 Baseline: 1.84	+120	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	47%	No estimated risk	
	Alternative: 2.32 Baseline: 1.64	+41					
22	Alternative: 3.28 Baseline: 3.24	+1	Moderate concern for dermal exposure ³ and low concern for inhalation exposure. ⁴	Low risk	17%	No estimated risk	
	Alternative: 6.04 Baseline: 3.20	+89					

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Formula Number	Private Costs ¹		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk ²	% VOC	Environmental Risk
23	Not tested		Possible concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	6%	No estimated risk
24	Alternative: 3.88 Baseline: 2.64	+47	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	19%	No estimated risk
	Alternative: 3.52 Baseline: 1.64	+115				
25	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	55%	No estimated risk
26	Alternative: 2.92 Baseline: 2.20	+33	Concern for dermal exposure and no concern for inhalation exposure. ⁴	Low risk	18%	No estimated risk
	Alternative: 1.88 Baseline: 2.00	-6				
27	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	93%	No estimated risk
29	Alternative: 3.72 Baseline: 2.28	+63	Low concern for dermal exposure ³ and no concern for inhalation exposure. ⁴	Low risk	30%	No estimated risk
	Alternative: 3.56 Baseline: 2.20	+62				
30	Alternative: 4.04 Baseline: 2.48	+63	Concern for dermal exposure and low concern for inhalation exposure. ³	Moderate risk	7%	No estimated risk
	Alternative: 2.48 Baseline: 2.12	+17				
31	Alternative: 6.36 Baseline: 2.28	+179	Concern for dermal exposure and low concern for inhalation exposure. ³	Moderate risk	99%	No estimated risk
	Alternative: 2.36 Baseline: 2.20	+7				
32	Alternative: 5.24 Baseline: 2.36	+122	Low to moderate concern for dermal and inhalation exposure. ³	Low risk	99%	No estimated risk
	Alternative: 1.72 Baseline: 2.12	-19				
33	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	46%	No estimated risk
34	Alternative: 3.56 Baseline: 2.36	+51	Concern for dermal exposure and low concern for inhalation exposure. ³	Moderate risk	39%	No estimated risk
	Alternative: 3.80 Baseline: 2.12	+79				

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Formula Number	Private Costs ¹		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk ²	% VOC	Environmental Risk
35	Not tested		Concern for dermal exposure and low concern for inhalation exposure.	Moderate risk	99%	No estimated risk
36	Not tested		Concern for dermal exposure and low concern for inhalation exposure. ³	Low risk	48%	No estimated risk
37	Alternative: 1.92	-13	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ³	High risk	14%	No estimated risk
	Baseline: 2.20					
38	Alternative: 3.16	-7	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ³	Low risk	65%	No estimated risk
	Baseline: 3.40					
39	Alternative: 4.32	+104	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ³	Low risk	65%	No estimated risk
	Baseline: 2.12					
40	Alternative: 4.44	+31	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ³	Low risk	65%	No estimated risk
	Baseline: 3.40					
39	Alternative: 2.76	+25	Low concern for dermal exposure and very low concern for inhalation exposure.	Low risk	52%	No estimated risk
	Baseline: 2.20					
40	Alternative: 3.20	+45	Low concern for dermal exposure and very low concern for inhalation exposure.	Low risk	52%	No estimated risk
	Baseline: 2.20					
40	Alternative: 3.16	+34	Concern for dermal exposure and low concern for inhalation exposure. ⁴	Low risk	52%	Aquatic species risk
	Baseline: 2.36					
40	Alternative: 3.48	-4	Concern for dermal exposure and low concern for inhalation exposure. ⁴	Low risk	52%	Aquatic species risk
	Baseline: 3.64					

¹ Cost analysis based upon product performance as determined by the performance demonstration at various testing facilities and pricing submitted by the product supplier. See Chapter 4 for a more in-depth description of the cost analysis and descriptions of the testing facilities.

² Flammability risks are defined as follows: 1) High Risk: products with a flash point less than 100°F; 2) Moderate Risk: products with a flash point greater than 100°F but less than 150°F; and Low Risk: products with a flash point greater than 150°F.

³ Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis.

⁴ Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based solely upon estimated exposure levels.

7.2.3 Potential Benefits

The potential social benefits associated with the use of a substitute blanket cleaner versus the baseline wash include: reduced health risks for workers and the general public, reduced risk of fire and explosion due to lower flammability, reduced ecological risks, reduced use of energy and natural resources, and reduced VOC emissions. In order to assess the risk to workers, the EPA risk assessment combines hazard and exposure data for individual chemical components of the substitute as well as the baseline products into a single qualitative expression of risk. This qualitative expression of risk provides the basis for comparing the relative worker exposure risks associated with the use of the substitute blanket wash products as compared with the baseline. While members of the general public are also potentially at risk from blanket wash chemicals that are released to air and water, the EPA risk assessment identified no concerns for the general

public through ambient air, drinking water, or fish ingestion. Due to data limitations, the exposure assessment does not estimate cumulative exposures from landfill releases or septic system releases. The relative risks of fire and explosion are determined by comparing the flash point of each blanket wash, using the OSHA definition of a flammable liquid as well as EPA's definition of an ignitable waste as a benchmark. In addition to the risks faced by workers and the general public, the risk assessment considers the potential ecological risks of using each of the alternative products and the baseline blanket wash. Several of the substitute formulations were found to present a risk to aquatic species. The energy and natural resource requirements of the substitute and the baseline blanket wash vary and a full life-cycle assessment, which was beyond the scope of this CTSA, would be needed to determine the requirements. The risks associated with volatile organic compound (VOC) releases were not examined within the risk assessment; however, the relative VOC contents of the substitute formulations are discussed below since VOC releases are the primary driving factor behind current regulations affecting printers.

Reduced Worker Health Risks

Reduced risks to workers can be considered both a private and an external benefit. Private worker benefits include reductions in worker sick days and reductions in health insurance costs to the printer. External worker benefits include reductions in medical costs to workers as well as reductions in pain and suffering associated with work related illnesses. The EPA risk assessment considers two paths of worker exposure: inhalation and dermal. Inhalation exposure results from the volatilization of blanket wash chemicals from the blanket during washing and from the rags used to wipe down the blanket. Dermal exposure results from direct contact with the blanket wash chemicals during blanket cleaning. Worker dermal exposure to all products can be easily minimized by using proper protective equipment such as gloves or barrier creams during blanket cleaning. Worker health risks associated with the use of any blanket wash product are a function of both the product's toxicity as well as the degree of worker exposure which occurs during blanket cleaning. For example, the worker health risks associated with the use of a more toxic blanket wash may be reduced by the product's low volatility (i.e., reduced inhalation exposure) or workplace practices such as the use of automatic blanket cleaning technology (i.e., reduced dermal exposure). The exposure assessment (Chapter 3) estimates worker exposure (dermal and inhalation) for each of the blanket wash products. The risk assessment (Chapter 3) evaluates the toxicity of the individual blanket wash components for the substitute and baseline products and integrates the hazard and exposure information into a single qualitative expression of risk. The risk assessment does not provide a single measure of risk for the products overall, making it difficult in some cases to determine the relative risk from one product to another. For example, blanket wash 22 contains heavy aromatic solvent naphtha and fatty acid esters which were determined to possess moderate dermal concern and low dermal concern, respectively.

Reduced Public Health Risk

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Such releases impose an external cost on society that is typically not considered by printing facilities in selecting their blanket wash. For example, people may breathe blanket wash vapors that have been released from a printing facility or people may drink water containing blanket wash residues discharged by a facility. Individuals in the general public that are exposed to blanket wash chemicals are therefore potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Reduced Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility (Table 7-3). Reduced flammability risk may result in both private and external benefits. Private benefits may accrue to the printer in the form of lower risk of fire damage to the print shop. The population surrounding the print shop may experience external benefits in the form of lower risks of fire damage to their homes. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.^d Flammable liquids are defined by OSHA as having a flash point less than 141°F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140°F or less. The baseline product has a flash point of 50°F, well below OSHA and EPA standards. Several of the substitute blanket washes have flash points below the OSHA and EPA thresholds: blanket washes 3, 4, 5, 8, 12, 21, 23, 24, 30, 31, 33, 34, 35, and 37.

Reduced Ecological Risk

Blanket wash formulations are potentially damaging to terrestrial and aquatic ecosystems, resulting in external costs borne by society. The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; however, only the risks to aquatic species were considered. Reductions in aquatic species risks may create external benefits by increasing the catch per unit effort for commercial fishers as well as by increasing catch and participation rates of recreational fishers. The following formulations were found to pose a risk to aquatic species: blanket washes 3, 5, 6, 8, 11, 18, and 20. All the chemicals of concern are amine salts of an alkylbenzene sulfonate. Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Conservation

Benefits may accrue to society (external) as well as the printer (private) in the form of energy and natural resource savings if substitute blanket washes are substituted for the baseline wash. For example, blanket wash 34 was found to require fewer impressions to get back to acceptable print quality than with the baseline wash, thereby consuming less paper and energy. A similar situation may occur with press wipes. By switching to the substitute blanket wash, the printer might experience lower energy and resource costs. At the same time, society would also benefit from the printer's reduction in energy and natural resource use. As discussed in Section 7.1, the analysis did not estimate the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

Reduced Volatile Organic Compound (VOC) Releases

The reduction of volatile organic compounds (VOCs) within the pressroom can potentially result in private benefits including lower compliance costs and savings on insurance premiums, as well as external benefits including a safer work environment and reduced health effects outside

^d Flash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

of the facility.^e VOCs are currently regulated under clean air legislation as well as toxics use and release reporting laws and, therefore, were not re-evaluated as part of the risk assessment. Because there are several sources of VOCs within any given print shop, no attempt was made to quantify the benefits associated with an incremental reduction in the release of blanket wash VOCs. However, case studies are available documenting the potential benefits of VOC reduction throughout the pressroom. For example, the Commonwealth of Massachusetts Office of Technical Assistance found that Hampden Papers of Holyoke, Massachusetts experienced savings by reducing VOCs (97 percent reduction over a ten year period).^f Hampden Papers, by adopting a source reduction strategy, has avoided the need to purchase VOC collection and control equipment or explosion-proof mixers for inks and coatings containing VOCs. In addition, they have incurred significant savings in fire insurance premiums, and reduced their liability under Superfund, air regulations, OSHA, RCRA, and other laws (OTA, no date). VOC content of the baseline as well as the alternative formulations, as measured by the GATF laboratory, are presented in Table 7-4. VOC content ranges from a low of 2 percent to a high of 99 percent. The baseline product and blanket wash 31 have the highest VOC content (99%).

7.2.4 Associated Costs

In comparing the cost data for the alternative and the baseline products, the costs of using the alternative blanket cleaners exceed the cost of using the baseline product in nearly all cases. Some cases required smaller quantities of wash or less cleaning time, resulting in a cost savings when using the substitute instead of the baseline wash. Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs of the using the substitute blanket washes range from a low of \$1.72 to a high of \$8.80 per press.^g Costs of using the baseline product range from \$1.64 to \$3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from one percent to 179 percent.

7.2.5 Costs and Benefits by Formulation

The objective of a social benefit/cost assessment is to identify those products or decisions that maximize net benefits. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products in terms of a single comparable unit (i.e., dollars) and calculate the net benefits of using the substitute instead of the baseline product. Due to data limitations, however, the analysis presents a qualitative description of the risks associated with each product compared to the baseline. Table 7-8 compares the relative risks and costs of each substitute blanket wash to the baseline. While this table presents a comparison between the blanket washes and the substitutes, it is important to keep in mind that not all of the risk assessments are based on risk (comprised of both exposure and hazard), but that some of the assessments are based solely on a hazard call based upon a structure-activity analysis. A frowning face (☹) indicates an increase in cost, worker health risks, flammability, risk to aquatic species,

^e A successful VOC reduction strategy can not be limited to blanket washes. All sources of VOC releases (i.e., inks, coatings, etc.) within the print shop must be evaluated in order to design and implement an efficient emissions control plan.

^f For a copy or further information about this case study, contact: Office of Technical Assistance (OTA), Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, Massachusetts 02202, or phone OTA at (617) 727-3260.

^g Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.

or VOC content when using the substitute blanket wash instead of the baseline product. A smiling face (☺) indicates a reduction in cost, worker risk, flammability, aquatic species risk, or VOC content when using the substitute instead of the baseline product. A zero (○) indicates that the risk assessment identified no difference in relative risks when using the substitute blanket cleaner instead of the baseline. Because the risk assessment evaluated individual blanket wash components, the relative worker health risks are based upon the component that poses the highest degree of concern. For example, components of Blanket Wash 32 were determined to pose no or low concern (propylene glycol ethers) and concern (aromatic and petroleum distillate hydrocarbons); therefore, the overall dermal risk of Blanket Wash 32 is one of concern. Blanket Wash 32 is shown to have similar relative dermal risks to workers when compared to the baseline because the baseline product's component of highest concern poses concern (i.e., petroleum distillate hydrocarbons).^h

In nearly every case the substitute product costs more to use than the baseline. There were several products whose use was determined to decrease dermal worker health risks; these were Blanket Washes 1, 9, 10, 14, 17, 19, 22, 23, 29, 37 and 38. Formulation 10 was found to increase costs by less than 10 percent for one of the facilities. The few products that did show evidence of reduced costs, had mixed results in terms of their relative health risks. For example, Blanket Wash 37, which was found to be less expensive to use than the baseline, was found to reduce worker dermal risks but was neutral in terms of relative inhalation risk. Blanket Washes 26 and 40 showed evidence of reduced costs; in addition, the risk assessment found that worker dermal risks were similar for both products over the baseline. In addition, while Blanket Wash 32 was less expensive than the baseline at one facility, it was found to present increased dermal and inhalation risks over the baseline. All of the substitute products had lower flash points and, therefore, reduced flammability risk when compared to the baseline. Finally, three blanket washes (6, 11, and 20) had higher aquatic risks than the baseline.

7.2.6 Potential Benefit of Avoiding Illness Linked to Exposure to Chemicals Commonly Used in Blanket Washing

As mentioned above, the risk assessment did not link exposures of concern to adverse health outcomes. Data do exist, however, on the cost of avoiding or mitigating certain illnesses that are linked to exposures to blanket wash chemicals. Such cost estimates indicate potential benefits associated with switching to less toxic products. Health endpoints potentially associated with blanket wash chemicals include: eye irritation, headaches, nausea, and asthma attacks. The following discussion presents estimates of the economic costs associated with each illness. To the extent that blanket wash chemicals are not the only factor contributing toward the illnesses described, individual costs may overestimate the potential benefits to society from substituting alternative blanket cleaners; also, this is not a comprehensive list of the potential health effects of exposure to blanket washes. For instance, inks and other pressroom chemicals may also contribute toward adverse worker health effects. The following discussion focuses on the external benefits of reductions in illness: reductions in worker medical costs as well as reductions in pain and suffering related to worker illness. However, private benefits, accrued by the decision-maker, may be incurred through increased worker productivity and a reduction in liability and health care insurance costs. While reductions in insurance premiums as a result of pollution prevention are not currently widespread, the opportunity exists for changes in the future.

Often adverse health effects are experienced when working with chemicals. For example, press operators at facility 12 experienced nausea and dizziness when using blanket wash 20, a petroleum based blanket wash containing petroleum distillates and aromatic hydrocarbons. In

^h The risk classification scheme should be interpreted as follows: no/low concern < low to moderate concern < concern.

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Table 7-8. Relative Benefits and Costs of Substitute Versus Baseline Blanket Wash ¹

Formula Number	Cost/Press		Worker Health Risk		Flammability Risk	Risk to Aquatic Species	VOC Content ²
	Facility #1	Facility #2	Dermal	Inhalation			
1	☹	☹	☹ ³	○ ³	☺	○	☺
3	Not tested		○	☹	☺	☹	☺
4	Not tested		○	○	☺	☹	☺
5	Not tested		○	○	☺	☹	☺
6	☹	☹	○	○	☺	☹	☺
7	Not tested		○	○	☺	☹	☺
8	Not tested		○	○	☺	☹	☺
9	☹	☹	☺	○	☺	☹	☺
10	☹	☹	☹ ³	○	☺	○	☺
11	☹	☹	○	○	☺	☹	☺
12	☹	☹	○	○	☺	○	☺
14	☹	☹	☹ ³	○	☺	○	☺
16	Not tested		○	○	☺	○	○
17	Not tested		☺	○	☺	☹	☺
18	Not tested		○	○	☺	☹	☺
19	☹	☹	☹ ³	○	☺	○	☺
20	☹	☹	○	○	☺	☹	☺
21	☹	☹	○	○	☺	○	☺
22	☹	☹	☹ ³	○	☺	○	NM
23	Not tested		☺	○	☺	○	☺
24	☹	☹	○	○	☺	☹	☺
25	Not tested		○	○	☺	○	☺
26	☹	☺	○	○	☺	○	☺
27	Not tested		○	○	☺	○	○
29	☹	☹	☺	○	☺	○	☺
30	☹	☹	○	○	☺	○	☺
31	☹	☹	○	○	☺	○	○

7.2 QUALITATIVE DISCUSSION OF BENEFIT/COST ANALYSIS

Formula Number	Cost/Press		Worker Health Risk		Flammability Risk	Risk to Aquatic Species	VOC Content ²
	Facility #1	Facility #2	Dermal	Inhalation			
32	☹	☺	☹	☹	☺	○	○
33	Not tested		○	○	☺	○	☺
34	☹	☹	○	○	☺	○	☺
35	Not tested		○	○	☺	○	○
36	Not tested		○	○	☺	○	☺
37	☺	☺	○	○	☺	○	☺
38	☹	☹	☺	○	☺	○	☺
39	☹	☹	☺	○	☺	○	☺
40	☹	☺	○	○	☺	☹	☺

¹ Baseline Blanket Wash is Formulation 28, VM&P naphtha. Information used to develop this table varies in the level of confidence. Please refer to earlier tables and to the development of each type of information for additional information.

² "NM" indicates that VOC content was not measured.

³ Level of concern for this substitute blanket wash based upon a structure-activity analysis of potential hazard.

addition, blanket wash 20 aggravated a previously existing respiratory condition in one press operator. The economic literature provides estimates of the costs associated with eye irritation, headaches, nausea, and asthma attacks, each of which may result from exposure to blanket wash chemicals. An analysis summarizing the existing literature on the costs of illness estimates individual willingness-to-pay to avoid certain acute effects for one symptom day (Unsworth and Neumann, 1993). The estimates for eye irritation, headaches, nausea, and asthma attacks are all based upon a survey approach designed to illicit estimates of individual willingness-to-pay to avoid a given illness. Such surveys, when properly designed, should capture direct treatment costs, indirect costs, and costs associated with pain and suffering.ⁱ As eye irritation, headaches, nausea, and asthma attacks typically occur as short-term, discrete incidents, cost estimates represent an individual's willingness-to-pay to avoid a single incidence and not the average lifetime cost of treating a disease. Table 7-6 presents a summary of the low, mid-range, and high estimates of individual willingness-to-pay to avoid each of these health endpoints. These estimates provide an indication of the benefit per affected individual that would accrue to society if switching to a substitute blanket wash product reduced the incidence of eye irritation, headaches, nausea, and asthma attacks.

ⁱ Several approaches are available for estimating the costs of illness. Appendix E provides a brief description of each.

**Table 7-9. Estimated Willingness-to-pay to Avoid Morbidity Effects
for One Symptom Day (1995 dollars)**

Health Endpoint	Low (\$)	Mid-Range (\$)	High (\$)
Eye Irritation ¹	20.79	20.79	46.14
Headache ²	1.67	13.23	66.72
Nausea ¹	29.11	29.11	83.66
Asthma Attack ³	15.62	42.96	71.16

Sources:

¹ Tolley, G.S., et al. 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. University of Chicago. Final Report for the U.S. EPA. January. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

² Dickie, M., et al. 1987. *Improving Accuracy and Reducing Costs of Environmental Benefit Assessments*. U.S. EPA, Washington, DC, September, and Tolley, G.S., et al. 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. University of Chicago. Final Report for the U.S. EPA. January. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

³ Rowe, R.D. and L.G. Chestnut. 1986. *Oxidants and Asthmatics in Los Angeles: A Benefit Analysis*. Energy and Resource Consultants, Inc. Report to U.S. EPA, Office of Policy Analysis, EPA-230-07-85-010. Washington, DC March 1985. Addendum March 1986. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

7.3 OVERVIEW OF RISK, COST AND PERFORMANCE

This section gives an overview of the substitute blanket washes including information regarding performance, cost, risk and exposure, and regulatory concerns. Since these evaluation factors are unique to each formulation, an individual profile was developed for each of the substitute blanket washes. The results of the process safety and general population risk analyses are similar for all formulations (see Sections 3.5 and 3.4.4, respectively). The profile summarizes information from various sections of the CTSA as described below.

Chemical Information

The generic chemical composition of each substitute blanket wash is provided. The categorization of blanket wash chemicals used to genericize the formulations was described in detail in Section 2.1. Also included in each profile are the flash point, VOC content, and pH of each substitute wash, which were determined during laboratory testing by the Graphic Arts Technical Foundation (GATF) (see also Table 4-1).

Performance

The performance section of the profile summarizes information collected during laboratory and production run performance demonstrations with each substitute blanket wash. The data on

wipability and blanket swell were determined in laboratory evaluations conducted by the GATF (see also Table 4-1).

Wipability is based on the number of strokes required to remove a standard volume of either wet or dry ink from the test blanket using a measured volume of the substitute blanket wash. Washes for which more than 100 strokes were required to clean the blanket were eliminated from field testing. The blanket swelling potential of each substitute wash was determined by measuring the thickness of the test blanket before and after exposure to the substitute blanket wash for one and five hours. Washes for which the blanket swell exceeded 3 percent after 5 hours were eliminated from field testing.

Based on the laboratory test results, 22 products qualified for further evaluation through field demonstrations. Each of the 22 substitutes was demonstrated at two facilities, and performance was compared to a standard baseline wash (VM&P naphtha). Qualitative performance evaluations were made by DfE observers and printers at the test facilities (see also Table 4-2).

Cost

A cost analysis was conducted for the 22 field-tested substitute blanket washes and the baseline wash. The primary source of information for the cost estimates was the performance demonstrations. The specific assumptions and methodology used in the analysis are discussed in detail in Section 4.2. In general, the data for cost per wash were based on estimates for labor, blanket wash, and material costs. The cost per press was calculated by multiplying the cost per wash by the estimated number of blankets per press. The annual cost was calculated by multiplying the total cost per press by the number of washes per shift, the number of shifts per week, and the number of weeks worked per year. The percent change refers to the percent increase or decrease that the facility would incur if it switched from using the baseline (VM&P naphtha) to using the substitute blanket wash. These data were extracted from Table 4-3. The number of times the blanket wash was used by the printing facility provides the number of data points, i.e., the sample size.

Risk and Exposure

This section of the profile addresses the risks that may result from the substitute blanket washes under typical conditions of use. The risk characterization integrates hazard and exposure information into quantitative and qualitative expressions of risk. The specific assumptions and methodology used to estimate occupational exposure are described in detail in Section 3.2. The risk characterization methodology is discussed in detail in Section 3.4.1 and 3.4.3.

Separate risk estimates are presented for dermal and inhalation exposure. Most of the formulations (27 of the 37 formulations including the baseline) present at least some concern for dermal exposures to workers primarily due to relatively high potential exposure levels. In contrast, worker inhalation risks are very low for almost all of the formulations, reflective of the generally low exposure levels.

Flammability risks are defined as follows: 1) High Risk: products with a flash point less than 100°F; 2) Moderate Risk: products with a flash point greater than 100°F but less than 150°F; and Low Risk: products with a flash point greater than 150°F.

Environmental risks are also presented. Only those formulations containing alkyl benzene sulfonates or ethoxylated nonylphenols presented a possible risk to aquatic species. The methodology and specific results can be found in Section 3.4.2.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Regulatory Concerns

This section identifies the substitute blanket washes that may trigger federal environmental regulations. Discharges of blanket wash chemicals may be restricted by air, water, and solid waste regulations; in addition, facilities may be required to report releases of some blanket wash products. It is important to note that this analysis is based on the generic chemical composition. Specific blanket wash chemicals that trigger federal environmental regulations (and one occupational health regulation) are given in Table 2-6. They are:

- Clean Water Act (CWA)
- Clean Air Act (CAA), Section 112B - Hazardous Air Pollutants
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Superfund Amendments and Reauthorization Act (SARA), Section 313
- Superfund Amendments and Reauthorization Act (SARA), Section 104
- Resource Conservation and Recovery Act (RCRA)
- Occupational Safety and Health Act (OSHA)

The generic category for these chemicals (based on Table 2-1) was compared to the generic compositions of the substitute blanket washes.

Blanket Wash Formulation 1*Composition:*

Fatty acid derivatives
 Alkoxylated alcohols

VOC Content: 30%; 2.3 lbs/gal
 Flashpoint: 230+ °F
 pH: 7.8 (fluctuates wildly)

Performance

Wipability:	wet ink- 4 strokes dry ink- 6 strokes	Blanket swell: 1 hr.- 1.5% 5 hrs.- 3.0%
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The performance of Blanket Wash 1 was demonstrated at two facilities. Facility 3 based their performance evaluation on a sample size of ten blanket washes and printed with conventional inks. This facility found that the wash yielded good performance for light or medium ink coverage but poor performance for heavy ink coverage. The extra time and effort required for heavy ink coverage were unacceptable. The wash also left a slight residue that was removed with a dry rag.

Facility 6 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash yielded poor performance, and resulted in print quality problems. The image of the previous job was still showing. Facility 6 did not use alternative product 1 for the full week-long demonstration, discontinuing use after experiencing print quality problems believed to have been attributable to use of the alternative product.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 1 instead of the baseline product at both facilities 3 and 6. Performance results indicate a 25 percent increase and a 70 percent increase in cleaning times at facilities 3 and 6, respectively. The costs associated with product use (i.e., volume x price) are also significantly higher for Blanket Wash 1 when compared to the baseline, driven primarily by the product's high price. The manufacturer's price for product 1 is \$20/gallon versus \$5.88/gallon for the baseline product. Costs associated with product use increased roughly 220 percent and 160 percent for facilities 3 and 6, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
3	\$0.69	\$2.76	\$6,900.00	\$5,500.00	+25
6	\$0.87	\$3.48	\$8,700.00	\$4,600.00	+89

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 1. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. However, overall concern is low because of low inhalation exposure levels, poor dermal absorption, and low to moderate toxicologic concern based on structure-activity analysis.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 3

Composition:

Hydrocarbons, petroleum distillates
Fatty acid derivatives
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 91%; 6.4 lbs/gal
Flashpoint: 114°F
pH: 3.4 (fluctuates wildly)

Performance

Wipability:	wet ink- 4 strokes	Blanket swell: 1 hr.- 1.5%
	dry ink- 4 strokes	5 hrs.- 4.5%

The performance of Blanket Wash 3 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 3 were not developed.

Risk and Exposure

Dermal Exposure: Hazard quotient calculations indicate a concern for exposure to some aromatic hydrocarbons and very low concern for exposure to other aromatic hydrocarbons. However, the hazard values are based upon oral or inhalation studies. Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons. However, the hazard values are based upon inhalation studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Inhalation Exposure: Hazard quotient calculations indicate very low concern for exposure to aromatic hydrocarbons. However, the hazard value for one of these aromatic hydrocarbons is based upon an oral study. The RfD used to calculate the risk estimate is classified as "low confidence" by IRIS (Integrated Risk Information System). Margin of exposure calculations indicate concern for exposure to certain aromatic hydrocarbons, but very low concern for exposure to others. Due to negligible inhalation exposure, the alkyl benzene sulfonates and fatty acid derivatives used in this formulation present no concern. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 4

Composition:

Terpenes
Ethoxylated nonylphenol

VOC Content: 89%; 6.4 lbs/gal

Flashpoint: 114 °F

pH: 8.7

Performance

Wipability:	wet ink- 3 strokes	Blanket swell: 1 hr.- 3.0%
	dry ink- 2 strokes	5 hrs.- 5.2%

The performance of Blanket Wash 4 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 4 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and low concern for exposure to ethoxylated nonylphenols. However, the hazard value for terpenes is based upon an oral study.

Inhalation Exposure: Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, no concern exists for exposure to the ethoxylated nonylphenols.

Flammability: Moderate risk

Environmental: Aquatic species risk due to presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 5

Composition:

Water
Hydrocarbons, aromatic
Ethylene glycol ethers
Ethoxylated nonylphenol
Alkyl benzene sulfonates
Alkoxyated alcohols
Alkali/salts

VOC Content: 30%; 2.5 lbs/gal

Flashpoint: 139°F

pH: 4.3

Performance

Wipability:	wet ink- 9 strokes	Blanket swell: 1 hr.- 6.1%
	dry ink- 8 strokes	5 hrs.- 15.4%

The performance of Blanket Wash 5 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 5 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons and ethylene glycol ethers, and very low concern for exposure to ethoxylated nonylphenols. However, the hazard value for aromatic hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons and ethylene glycol ethers. Due to negligible exposure, no concern exists for the other chemicals in this formulation.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates and ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Ethylene glycol ethers		X		X		
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 6

Composition:

Fatty acid derivatives
Hydrocarbons, petroleum distillates
Solvent naphtha (petroleum), heavy aromatic
Alkyl benzene sulfonates

VOC Content: 47%; 3.5 lbs/gal

Flashpoint: 152°F

pH: 5.5

Performance

Wipability: wet ink- 8 strokes Blanket swell: 1 hr.- 0.7%
 dry ink- 6 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 6 was demonstrated at two facilities. Facility 11 based their performance evaluation on a sample size of 11 blanket washes and printed with conventional and vegetable-based inks. This facility found that the wash left an oily residue that interfered with print quality. Due to its thick consistency, the wash did not readily absorb into rags creating delays. In addition, this facility found that more effort was required with heavy ink coverage. This facility felt that Blanket Wash 6 yielded fair performance results overall.

Facility 15 based their performance evaluation on a sample size of 23 blanket washes and printed with conventional inks. This facility also noted that the blanket wash did not readily absorb into rags due to its thick consistency. This created delays in cleaning, and prompted this facility to rate the cleaning effort as "high." However, this facility felt that Blanket Wash 6 cut the ink well and did not leave a residue on the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 6 instead of the baseline. Costs for facilities 11 and 15 increased roughly 20 percent and 50 percent respectively when using Blanket Wash 6 instead of the baseline. Performance results indicate an 11 percent increase and a 69 percent increase in cleaning times at facilities 11 and 15, respectively. Despite a 30 percent decrease in the average quantity of blanket wash used, facility 15 experienced a 60 percent increase in costs associated with blanket wash use (i.e., volume x price) due to a product cost of more than twice the baseline cost (\$12.35/gallon for product 6 compared to \$5.88/gallon for the baseline product). Facility 11 experienced a 20 percent increase in product use, with a subsequent increase of 170 percent in costs associated with product use.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
11	\$0.82	\$3.28	\$8,200	\$7,000	+17
15	\$0.77	\$3.08	\$7,700	\$5,000	+54

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 6. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margins of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon inhalation studies. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The fatty acid derivatives and alkyl benzene sulfonates are of low concern due to their expected low rate of dermal absorption and low to moderate hazard.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, the petroleum distillate hydrocarbons, alkyl benzene sulfonates, and fatty acid derivatives used in this formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 7

Composition:

Terpenes
Ethoxylated nonylphenol
Alkoxyated alcohols

VOC Content: 36%; 3.0 lbs/gal
Flashpoint: 165 °F
pH: 9.3

Performance

Wipability:	wet ink- 6 strokes	Blanket swell: 1 hr.- 3.8%
	dry ink- 8 strokes	5 hrs.- 6.8%

The performance of Blanket Wash 7 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 7 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and very low concern for exposure to ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values, although none of the chemicals present more than a low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 8

Composition:

Water
Hydrocarbons, aromatic
Propylene glycol ethers
Alkyl benzene sulfonates
Ethoxylated nonylphenol
Alkoxyated alcohols
Alkali/salts

VOC Content: 41%; 3.3 lbs/gal

Flashpoint: 115°F

pH: 4.0

Performance

Wipability:	wet ink- 7 strokes	Blanket swell: 1 hr.- 7.7%
	dry ink- 9 strokes	5 hrs.- 20%

The performance of Blanket Wash 8 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 8 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for propylene glycol ethers and very low concern for ethoxylated nonylphenol. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicated a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The other compounds in the formulation present low to moderate hazard concerns.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon a subacute oral study. Due to low or negligible inhalation exposure, other chemicals in the formulation present little or no concern.

Flammability: Moderate risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates and ethoxylated nonylphenols.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkali/salts	X		X			
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 9*Composition:*

Fatty acid derivatives
Water
Ethoxylated nonylphenol

VOC Content: 10%; 0.77 lbs/gal
Flashpoint: 230+°F
pH: 4.6

Performance

Wipability: wet ink- 19 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 30 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 9 was demonstrated at two facilities. Facility 10 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash yielded poor performance overall. The wash did not cut ink well, required excessive effort for cleaning, and did not soak into the rag. For these reasons, this facility discontinued using Blanket Wash 9 after four washes.

Facility 15 based their performance evaluation on a sample size of 21 blanket washes and printed with conventional inks. This facility also found that the wash yielded poor performance and that the wash did not soak into the rag. This facility felt that using Blanket Wash 9 required much more effort than using the baseline.

Cost

Blanket washing costs increase significantly when using Blanket Wash 9 as compared to the baseline product at facilities 10 and 15. Costs increased 129 percent and 84 percent at facilities 10 and 15 respectively when compared to the baseline. Performance data indicate that increased cleaning times are the driving force behind the cost increases experienced by both facilities. Cleaning times increase 175 percent and 129 percent when compared to the baseline at facilities 10 and 15, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
10	\$2.08	\$8.32	\$20,800	\$9,100	+129
15	\$0.92	\$3.68	\$9,200	\$5,000	+84

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 9. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate a very low concern for ethoxylated nonylphenol. Risks for the fatty acid derivative could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption.

Inhalation Exposure: Due to negligible inhalation exposure, the chemicals used in this formulation present no concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 10*Composition:*

Fatty acid derivatives
Water

VOC Content: 2%; 0.16 lbs/gal
Flashpoint: 230+ °F
pH: 5.7

Performance

Wipability: wet ink- 12 strokes Blanket swell: 1 hr.- 0.7%
 dry ink- 13 strokes 5 hrs.- 0.7%

The performance of Blanket Wash 10 was demonstrated at two facilities. Both facilities 3 and 4 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. Both facilities declined to further test the blanket wash due to the level of effort required to clean the blankets. Blanket Wash 10 did not absorb well into the rags and did not cut ink well at either facility.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 10. Blanket washing costs increased 4 percent at facility 3 and 160 percent at facility 4 when Blanket Wash 10 is used rather than the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
3	\$0.57	\$2.28	\$5,700	\$5,500	+4
4	\$2.20	\$8.80	\$22,000	\$8,500	+159

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 10. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risk for this formulation could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption of the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 11*Composition:*

Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 61%; 4.3 lbs/gal
Flashpoint: 150°F
pH: 5.0 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes Blanket swell: 1 hr.- 0.0%
 dry ink- 5 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 11 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of 26 blanket washes and printed with vegetable-based inks. This facility found that the blanket wash yielded good performance results from light to medium ink coverage, but poor performance results for heavy ink coverage due to the extra time and effort required. This facility found that the blanket wash left a slight, oily residue on the blanket, although this did not affect the print quality.

Facility 2 based their performance evaluation on a sample size of 31 blanket washes and printed with conventional and vegetable-based inks. This facility found that the blanket wash yielded good to fair performance results for light to medium ink coverage but poor performance for heavy ink coverage due to the extra product, time and effort required. This facility also found that the blanket wash left a slight, oily residue on the blanket which did not affect the print quality.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 11 instead of the baseline. Overall costs per wash at facilities 1 and 2 increased roughly 120 percent and 30 percent respectively when using Blanket Wash 11 instead of the baseline. Costs associated with product use (i.e., volume x price) are driven by the higher price of Blanket Wash 11 as compared to the baseline. Blanket Wash 11 is priced at \$12.15/gallon compared to \$5.88/gallon for the baseline product. Material costs (i.e., press wipes) increased by roughly 210 percent and 140 percent at facility 1 and 2, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost*	Baseline Cost*	% Change**
1	\$1.29	\$5.16	\$12,900	\$5,900	+119
2	\$0.68	\$2.72	\$6,800	\$5,300	+28

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 11. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to the petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. The alkyl benzene sulfonates are of low concern due to their expected low rate of dermal absorption and low to moderate hazard.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 12*Composition:*

Hydrocarbons, petroleum distillates

Water

VOC Content: 20%; 1.3 lbs/gal

Flashpoint: 125°F

pH: 8.2

Performance

Wipability: wet ink- 7 strokes Blanket swell: 1 hr.- 0.0%
 dry ink- 11 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 12 was demonstrated at two facilities. Facility 12 based their performance evaluation on a sample size of 16 blanket washes and printed with conventional inks. The wash was diluted 50% with water. This facility noted that the wash caused potential print quality problems. This facility also found that the wash had difficulty cutting paper residue and discontinued use of the wash on paper residue coated blankets. Nevertheless, the wash was considered equal to baseline in overall performance.

Facility 13 based their performance evaluation on a sample size of 19 blanket washes and printed with conventional inks. This facility considered the overall performance of the wash to be fair across ink coverages and dilutions. When not diluted with water, performance surpassed baseline and standard washes. The wash required slightly less effort than the baseline wash when averaged over all dilution levels.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 12 instead of the baseline. Average costs per wash increased roughly 20 percent and 5 percent at facilities 12 and 13, respectively. At a cost of \$16.40/gallon, however, Blanket Wash 12 would not be economically competitive with the baseline (\$5.88/gallon) unless the average quantity used was significantly lower.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
12	\$0.99	\$3.96	\$9,900	\$8,100	+22
13	\$0.83	\$3.32	\$8,300	\$8,000	+4

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 12. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risk could not be quantified, but structure-activity analysis indicates a low to moderate hazard concern.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risk could not be quantified but is expected to be low due to low exposure and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 14*Composition:*

Fatty acid derivatives
Propylene glycol ethers
Water

VOC Content: 12%; 0.97 lbs/gal
Flashpoint: 230+°F
pH: 5.0

Performance

Wipability: wet ink- 8 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 10 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 14 was demonstrated at two facilities. Facility 6 based their performance evaluation on a sample size of 15 blanket washes and printed with conventional inks. This facility found that the wash cut ink well, and the performance was good. The facility noted that extra effort was required to remove the oily residue that the wash left on the blanket.

Facility 16 based their performance evaluation on a sample size of 34 blanket washes and printed with conventional inks and printed with conventional inks. This facility found that the substitute wash did not cut ink as well as the baseline wash. Black inks and heavy ink build up were especially difficult to clean. In addition, the thick consistency of the wash made it difficult to soak into the rag.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 14 instead of the baseline product at both facilities 6 and 16. Compared to the baseline, total costs per wash increased 133 percent at facility 6 and 24 percent at facility 16. The average cleaning time increased significantly at facility 6 compared to the baseline, requiring an additional minute per wash. Despite a decrease in the average cleaning time, overall costs per wash at facility 16 increase, driven primarily by the product's higher price. Blanket Wash 14 is priced at \$9.55/gallon compared to \$5.88/gallon for the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
6	\$1.07	\$4.28	\$10,700	\$4,600	+133
16	\$0.82	\$3.28	\$8,200	\$6,600	+24

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 14. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified but are expected to be low based on structure-activity predictions of low toxicity for both the fatty acid derivatives and the propylene glycol ethers. Also, the fatty acid derivatives are expected to be poorly absorbed.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern. Risks for the propylene glycol ether are also expected to be low due to low exposure and its predicted low toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 16

Composition:

Terpenes

VOC Content: 99%; 7.2 lbs/gal

Flashpoint: 145°F

pH: 9.8

Performance

Wipability: wet ink- 2 strokes
 dry ink- 2 strokes

Blanket swell: 1 hr.- 4.5%
 5 hrs.- 10.6%

The performance of Blanket Wash 16 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 16 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analyses of these compounds indicate low to moderate hazard concerns.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value for terpenes is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low due to low exposures and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 17*Composition:*

Ethoxylated nonylphenol
 Glycols
 Fatty acid derivatives
 Alkali/salts
 Water

VOC Content: 0.6%; 0.051 lbs/gal

Flashpoint: 220+ °F

pH: 9.8

Performance

Wipability: wet ink- 100 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 100 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 17 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 17 were not developed.

Risk and Exposure

Dermal Exposure: Hazard quotient calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon an oral study. Margin of exposure calculations indicate very low concern for ethoxylated nonylphenols and alkali/salts. However, the hazard value for alkali/salts is based upon oral values. The alkanolamine component of the fatty acid derivative/alkanolamine salt presents a possible concern. However, dermal absorption of the alkanolamine salt is likely to be lower than that of free alkanolamine.

Inhalation Exposure: Hazard quotient calculations indicate no concern for glycols. However, the hazard value is based upon an oral study. Due to negligible inhalation exposure, ethoxylated nonylphenol, fatty acid derivatives and alkali/salts present very low concern.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Alkali/salts	X		X			

Blanket Wash Formulation 18

Composition:

Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Dibasic esters
Esters/lactones
Alkyl benzene sulfonates

VOC Content: 60%; 4.4 lbs/gal

Flashpoint: 150°F

pH: 5.5

Performance

Wipability:	wet ink- 8 strokes	Blanket swell: 1 hr.- 1.5%
	dry ink- 7 strokes	5 hrs.- 4.5%

The performance of Blanket Wash 18 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 18 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and dibasic esters. However, the hazard values are based on inhalation studies. Risk from the alkyl benzene sulfonates could not be quantified but is expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Risk from esters/lactones is also expected to be low based on structure-activity predictions of low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and dibasic esters. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Flammability: Not available

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 19

Composition:

Fatty acid derivatives
Propylene glycol ethers
Water

VOC Content: 22%; 1.8 lbs/gal
Flashpoint: 230+°F
pH: 4.6

Performance

Wipability: wet ink- 11 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 9 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 19 was demonstrated at two facilities. Facility 18 based their performance evaluation on a sample size of 5 blanket washes and printed with soy oil-based inks. This facility noted that the thick consistency of the wash made it difficult to soak into the rag, which resulted in uneven application. Large quantities were required to cut ink.

Facility 19 based their performance evaluation on a sample size of 8 blanket washes and printed with soy oil-based inks. This facility noted that the thick consistency of the wash was messy and difficult to use. The demonstration was cut short due to the extra effort and time required to clean the blanket.

Cost

The results of the performance data indicate an increased financial cost when using Blanket Wash 19 instead of the baseline at both facilities 18 and 19. Overall costs per wash increased roughly 170 percent and 70 percent at facilities 18 and 19, respectively. This increase in cost was due in large part to an increase in cleaning and drying times. Press operators commented that cleaning and drying times were excessive, as reflected in the performance data; performance results indicate a 150 percent increase and a 60 percent increase in cleaning times at facilities 18 and 19, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
18	\$1.66	\$6.64	\$16,600	\$6,200	+168
19	\$0.89	\$3.56	\$8,900	\$5,300	+68

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 19. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be calculated due to the unavailability of hazard values. However, risks are expected to be low based on structure-activity predictions of low toxicity of propylene glycol ethers and poor absorption and low to moderate toxicity of the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives present no concern. Risks for propylene glycol ethers are expected to be low due to low exposure and low hazard concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 20*Composition:*

Water
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Alkyl benzene sulfonates

VOC Content: 35%; 2.7 lbs/gal
Flashpoint: 170°F
pH: 7.1

Performance

Wipability: wet ink- 5 strokes Blanket swell: 1 hr.- 0.0%
 dry ink- 7 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 20 was demonstrated at two facilities. Facility 11 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional and vegetable-based inks. This facility considered the performance of the wash to be fair, but worse than facility and baseline washes. The wash left an oily residue on the blanket that required additional rotations to remove. The wash also was hard to apply to rags due to its thick consistency.

Facility 12 based their performance evaluation on a sample size of one blanket wash and printed with conventional inks. The product induced nausea in press operators, and the facility discontinued the test.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 20 instead of the baseline. Average costs per wash increased roughly 60 percent and 95 percent at facilities 11 and 12, respectively. For facility 11, this increase is due in large part to an increase in cleaning times. Cleaning times at facility 11 increased from an average of 60 seconds for the baseline to an average of 100 seconds for Blanket Wash 20. The contribution of labor to the product cost for Facility 12 is based on only one observation.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
11	\$1.13	\$4.52	\$11,300	\$7,000	+61
12	\$1.58	\$6.32	\$15,800	\$8,100	+95

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 20. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard value. Risk from the alkyl benzene sulfonates is expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Structure-activity analysis

7.3 OVERVIEW OF RISK, COST AND PERFORMANCE

indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Flammability: Low risk

Environmental: Aquatic species risk is due to the presence of alkyl benzene sulfonates.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 21*Composition:*

Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates
Fatty acid derivatives

VOC Content: 47%; 3.5 lbs/gal
Flashpoint: 115°F
pH: 6.2

Performance

Wipability: wet ink- 7 strokes Blanket swell: 1 hr.- 0.0%
 dry ink- 6 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 21 was demonstrated at two facilities. Facility 6 based their performance evaluation on a sample size of 6 blanket washes and printed with conventional inks. This facility considered the performance of the wash to be fair. The wash cut ink well, but the oily residue was difficult to remove and began to affect subsequent runs. Extra waste sheets were required to get back up to color due to the residue.

Facility 17 based their performance evaluation on a sample size of 25 blanket washes and printed with conventional inks. This facility also considered the performance of the wash to be fair. This facility also found that the wash cut the ink well. The oily residue caused print problems if it was not completely removed. In addition, the wash did not absorb into the rag easily.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 21 instead of the baseline. Costs per wash increase roughly 120 percent at facility 6 and 40 percent at facility 17 when compared to the baseline. Extra wiping was required to clear the blanket as reflected in the performance data --- when compared to the baseline, average cleaning times increased roughly 110 percent for facility 6 and 50 percent for facility 17.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
6	\$1.01	\$4.04	\$10,100	\$4,600	+120
17	\$0.58	\$2.32	\$5,800	\$4,100	+41

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 21. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. However, the hazard values are based upon inhalation studies. Risk for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. Due to negligible exposure and predicted low toxicity and absorption, fatty acid derivatives present no concern.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 22*Composition:*

Fatty acids derivatives
Hydrocarbons, aromatic
Water

VOC Content: Not measured
Flashpoint: 157°F (full strength)
pH: 7.4 (25%)

Performance

Wipability: wet ink- 13 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 13 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 22 was demonstrated at two facilities. Facility 12 based their performance evaluation on a sample size of 5 blanket washes and printed with conventional inks. This facility considered the wash to be a fair performer overall. The substitute wash cut ink as well as the baseline, but it did not readily soak into the rag, creating delays.

Facility 13 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional inks. This facility also considered the wash to be a fair performer. The facility found that the wash was difficult to apply to the rag due to its thick consistency. In addition, the wash left the blanket slightly streaked and wet. As a result, extra drying time was required to prevent quality problems. The facility also found that the wash cut ink as well as baseline wash, but it required greater effort.

Cost

Performance data indicate mixed results for Blanket Wash 22. Total costs per wash increased 89 percent for facility 13, but increased only 1 percent for facility 12. Despite a 34 percent decrease in the average quantity used, costs associated with product use (i.e., volume x price) increased 50 percent for facility 12. Blanket Wash 22 is priced at \$13.15/gallon compared to a price of \$5.88/gallon for the baseline product. Average cleaning time increased 67 percent at facility 13 compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
12	\$0.82	\$3.28	\$8,200	\$8,100	+1
13	\$1.51	\$6.04	\$15,100	\$8,000	+89

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 22. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be calculated due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds.

7.3 OVERVIEW OF RISK, COST AND PERFORMANCE

Risks from the fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Inhalation Exposure: Risks could not be quantified but are expected to be low due to low or negligible exposures.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 23

Composition:

Terpenes
Nitrogen heterocyclics
Alkoxylated alcohols
Water

VOC Content: 6%; 0.48 lbs/gal
Flashpoint: 140°F
pH: 9.2

Performance

Wipability:	wet ink- 24 strokes	Blanket swell: 1 hr.- 0.0%
	dry ink- 100 strokes	5 hrs.- 1.5%

The performance of Blanket Wash 23 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 23 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate possible concerns for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on low exposure and structure-activity predictions of poor absorption and low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 24*Composition:*

Terpenes
 Ethylene glycol ethers
 Ethoxylated nonylphenol
 Alkyl benzene sulfonates
 Alkali/salts
 Water

VOC Content: 19%; 1.5 lbs/gal
 Flashpoint: 100°F
 pH: 9.9

Performance

Wipability: wet ink- 15 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 12 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 24 was demonstrated at two facilities. Facility 16 based their performance evaluation on a sample size of 28 blanket washes and printed with conventional inks. This facility found that the wash cut ink well. However, the wash left an oily residue, which required some extra effort to wipe off. In addition, the oily residue significantly increased the number of copies required to return to print quality.

Facility 17 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility also found that the wash cut ink well. Again, extra effort was required to wipe off the oily residue. In addition, the thick consistency of the wash caused the operator to curtail use. The operator felt that the citrus odor of the wash was very strong.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 24 instead of the baseline. Costs per wash increased roughly 50 percent at facility 16 and 110 percent at facility 17, when compared to the baseline. When compared to the baseline, average cleaning times increased 18 percent and 160 percent for facilities 16 and 17, respectively. Despite the fact that facility 17 used a smaller average quantity of Blanket Wash 24 compared to the baseline, the costs associated with blanket wash use (i.e., volume x price) increased due to a much higher price per gallon. The manufacturers price for product 24 is \$17.85/gallon versus \$5.88/gallon for the baseline product. Costs associated with product use (i.e., volume x price) increased roughly 220 percent and 160 percent for facilities 16 and 17, respectively.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
16	\$0.97	\$3.88	\$9,700	\$6,600	+47
17	\$0.88	\$3.52	\$8,800	\$4,100	+115

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 24. A "+" indicates an increase in cost, and a "-" indicates a decrease.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for alkyl benzene sulfonates and terpenes, possible concern for ethylene glycol ethers, and very low concern for ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for alkali/salts could not be quantified but are expected to be very low based on structure-activity predictions of no absorption and low to moderate toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes and ethylene glycol ethers. However, the hazard value for terpenes is based upon an oral study. Due to negligible exposure, the other chemicals in this formulation present no concern.

Flammability: Moderate risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Ethylene glycol ethers		X		X		
Alkali/salts	X		X			
Alkyl benzene sulfonates	X		X			

Blanket Wash Formulation 25*Composition:*Terpenes
Esters/lactones

VOC Content: 55%; 4.1 lbs/gal

Flashpoint: 220+ °F

pH: 4.3

Performance

Wipability:	wet ink- 22 strokes	Blanket swell: 1 hr.- 3.0%
	dry ink- 32 strokes	5 hrs.- 4.5%

The performance of Blanket Wash 25 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 25 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to terpenes and possible concern for exposure to esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to terpenes and esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 26*Composition:*

Fatty acids derivatives

Esters/lactones

VOC Content: 18%; 1.3 lbs/gal

Flashpoint: 230+°F

pH: 7.8 (fluctuates wildly)

Performance

Wipability:	wet ink- 6 strokes	Blanket swell: 1 hr.- 0.0%
	dry ink- 14 strokes	5 hrs.- 0.0%

The performance of Blanket Wash 26 was demonstrated at two facilities. Facility 5 based their performance evaluation on a sample size of 14 blanket washes and printed with conventional inks. This facility considered the performance to be good after every wash. The wash performed as well as both the standard facility wash and the baseline wash. However, a slight oily residue caused print quality problems when the wash was used for roller clean-up.

Facility 15 based their performance evaluation on a sample size of 22 blanket washes and printed with conventional inks. This facility also considered the performance to be good after every wash. Again, the wash performed as well as both the standard facility wash and the baseline wash.

Cost

Performance data indicate mixed results for Blanket Wash 26. Total costs per wash increased roughly 30 percent for facility 5, but decreased 6 percent at facility 15. Despite the fact that Blanket Wash 26 is priced higher than the baseline wash, differences in costs associated with product use (i.e., volume x price) did not contribute to the higher overall cost per wash at facility 5. Blanket Wash 26 is priced at \$12.24/gallon compared to a price of \$5.88/gallon for the baseline. Performance data indicate that the average quantity of blanket wash used at both facilities decreased by roughly 40 percent compared to the baseline. The savings experienced by facility 26 result from a 14 percent decrease in cleaning time compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
5	\$0.73	\$2.92	\$7,300	\$5,500	+33
15	\$0.47	\$1.88	\$4,700	\$5,000	-6

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 26. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for esters/lactones and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Due to negligible exposure, the chemicals used in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 27

Composition:

Terpenes

VOC Content: 93%; 7.2 lbs/gal

Flashpoint: 145°F

pH: 3.9

Performance

Wipability:	wet ink- 3 strokes	Blanket swell: 1 hr.- 3.0%
	dry ink- 3 strokes	5 hrs.- 4.5%

The performance of Blanket Wash 27 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 27 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 28

Composition:

Hydrocarbons, petroleum distillates

VOC Content: 100%; 6.2 lbs/gal

Flashpoint: 50°F

pH: 6.6

Performance

Wipability:	wet ink- 3 strokes	Blanket swell: 1 hr.- 1.5%
	dry ink- 8 strokes	5 hrs.- 3.0%

The performance of Blanket Wash 28 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 28 were not developed.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a low to moderate concern for petroleum distillate hydrocarbons.

Flammability: Not available

Environmental: Not available

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 29*Composition:*

Fatty acid derivatives

VOC Content: 30%; 2.1 lbs/gal

Flashpoint: 230+ °F

pH: 7.2

Performance

Wipability: wet ink- 9 strokes
 dry ink- 18 strokes

Blanket swell: 1 hr.- 1.5%
 5 hrs.- 1.5%

The performance of Blanket Wash 29 was demonstrated at two facilities. Facility 7 based their performance evaluation on a sample size of three blanket washes and printed with conventional inks. This facility considered the performance of the wash to be good. The wash cut ink well; however, extra effort was required to dry the blanket.

Facility 8 based their performance evaluation on a sample size of 36 blanket washes and printed with conventional inks. This facility noted that the wash did not cut ink as well as the baseline wash and did not cut paper dust or powder. In addition, a slightly oily film remained on the blanket, which required more effort to remove.

Cost

Using Blanket Wash 29 rather than the baseline, costs per press increased roughly 60 percent at both facilities 7 and 8. Blanket Wash 29 is priced three-times higher than the baseline, contributing significantly to the higher overall costs associated with its use. Costs associated with product use (i.e., volume x price) increase 300 percent and 230 percent at facilities 7 and 8 respectively due primarily to the products higher price. Blanket Wash 29 is priced at \$18.00/gallon compared to a price of \$5.88/gallon for the baseline. In addition, average cleaning times are higher for Blanket Wash 29 compared to the baseline for both facilities. Cleaning times increased 22 percent for facility 7 and 64 percent for facility 8.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
7	\$0.93	\$3.72	\$9,300	\$5,700	+63
8	\$0.89	\$3.56	\$8,900	\$5,500	+62

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 29. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity for the fatty acid derivatives.

Inhalation Exposure: Due to negligible exposure, the chemicals in this formulation present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 30

Composition:

Hydrocarbons, aromatic
Propylene glycol ethers
Water

VOC Content: 7%; 0.48 lbs/gal
Flashpoint: 100°F (full strength)
pH: 7.6 (25%)

Performance

Wipability: wet ink- 5 strokes Blanket swell: 1 hr.- 0.7%
 dry ink- 11 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 30 was demonstrated at two facilities. Facility 18 based their performance evaluation on a sample size of three blanket washes and printed with soy oil-based inks. This facility considered the performance of the wash to be good. This facility noted that the wash cut ink well and worked best when not diluted with water.

Facility 19 based their performance evaluation on a sample size of eight blanket washes and printed with soy oil-based inks. This facility also noted that the wash cut ink well. However, the wash left an oily film on the blanket, which required extra effort to dry. In addition, the thick consistency of the wash was difficult to use, and extra effort was required due to its resistance to the surface of the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 30 instead of the baseline. Compared to the baseline, costs per wash increased roughly 60 percent at facility 18 and 20 percent at facility 19. Increased cleaning time was the primary contributor to the higher cost per wash for both facilities. According to the performance data, cleaning times at facility 18 increased from an average of 48 seconds for the baseline to an average of 82 seconds for Blanket Wash 30; however, this alternative was only tested under heavy ink coverage conditions and the baseline wash was observed under light and medium coverage conditions. The press operator at facility 19 commented that Blanket Wash 30 evaporated slowly; cleaning times for the alternative increased by roughly 30 percent, compared to the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
18	\$1.01	\$4.04	\$10,100	\$6,200	+63
19	\$0.62	\$2.48	\$6,200	\$5,300	+17

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 30. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for propylene glycol ethers could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low hazard concern for propylene glycol ethers.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for propylene glycol ethers could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 31*Composition:*

Hydrocarbons, aromatic
Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.6 lbs/gal

Flashpoint: 105°F

pH: 7.6

Performance

Wipability:	wet ink- 3 strokes	Blanket swell: 1 hr.- 1.5%
	dry ink- 3 strokes	5 hrs.- 3.0%

The performance of Blanket Wash 31 was demonstrated at two facilities. Facility 7 based their performance evaluation on a sample size of four blanket washes and printed with conventional inks. This facility found that the wash cut ink well. However, the wash left an oily residue on the blanket, which required slightly more effort to remove. In addition, the oily residue slightly increased the number of copies required to return to print quality. The facility noted that the smell was not as strong as the facility's standard wash or the baseline wash.

Facility 8 based their performance evaluation on a sample size of 61 blanket washes and printed with conventional inks. This facility also found that the wash cut ink well. The wash performed as well as the standard wash, and the facility considered the performance to be good. Slightly more effort was required due to the resistance of the wash to the surface of the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 31 instead of the baseline. Compared to the baseline, costs per wash increased roughly 180 percent at facility 7 and 7 percent at facility 8. The press operator at facility 7 observed that drying times for Blanket Wash 31 were greater than the baseline; cleaning times averaged 140 seconds for Blanket Wash 31, compared to 45 seconds for the baseline product. The press operator at facility 8 experienced a decrease in cleaning time, but an increase in the quantity of blanket wash used. According to the performance data, cleaning times at facility 8 decreased by 4 percent compared to the baseline. The average quantity of blanket wash used, however, increases roughly 60 percent, off-setting the gains in labor savings.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
7	\$1.59	\$6.36	\$15,900	\$5,700	+179
8	\$0.59	\$2.36	\$5,900	\$5,500	+7

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 31. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for exposure to aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 32*Composition:*

Hydrocarbons, petroleum distillates

VOC Content: 99%; 6.5 lbs/gal

Flashpoint: 220°F

pH: 8.5

Performance

Wipability:	wet ink- 5 strokes	Blanket swell: 1 hr.- 0.1%
	dry ink- 30 strokes	5 hrs.- 1.5%

The performance of Blanket Wash 32 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of four blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. However, the substitute wash required slightly higher effort to remove excess wash than the standard wash. The substitute wash left an oily-residue on the blanket affecting subsequent print quality.

Facility 5 based their performance evaluation on a sample size of 12 blanket washes and printed with conventional inks. This facility also considered the performance of the wash to be good. The substitute wash left a slight, oily residue that was removed with dry rags; the residue did not affect print quality.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 32. Total costs per wash increased roughly 120 percent at facility 1, but decreased 20 percent at facility 5. Material costs (i.e., press wipes) contributed significantly to the higher costs per wash observed at facility 1. Costs associated with material use increased roughly 160 percent compared to the baseline. Facility 5 reported lower cleaning times and reduced blanket wash use for Blanket Wash 32, compared to the baseline. Performance results indicate a 15 percent decrease in cleaning time and a 60 percent decrease in the quantity of blanket wash used for facility 5.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
1	\$1.31	\$5.24	\$13,100	\$5,900	+122
5	\$0.43	\$1.72	\$4,300	\$5,300	-19

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 32. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 33*Composition:*

Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Propylene glycol ethers
Water

VOC Content: 46%; 3.4 lbs/gal
Flashpoint: 105°F
pH: 7.2 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes Blanket swell: 1 hr.- 4.5%
 dry ink- 4 strokes 5 hrs.- 7.6%

The performance of Blanket Wash 33 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 33 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and aromatic hydrocarbons and very low concern for propylene glycol ethers. However, the hazard values for petroleum distillate hydrocarbons and aromatic hydrocarbons are based upon an inhalation study.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, aromatic hydrocarbons, and propylene glycol ethers.

Flammability: Not available

Environmental: Not available

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 34*Composition:*

Water
 Terpenes
 Hydrocarbons, petroleum distillates
 Alkoxylated alcohols
 Fatty acid derivatives

VOC Content: 39%; 2.8 lbs/gal
 Flashpoint: 138°F
 pH: 6.6

Performance

Wipability: wet ink- 10 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 20 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 34 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of 37 blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. The wash cut the ink well with the same effort as with the standard wash for light/medium ink coverage. For heavy ink coverage, slightly more effort was required, but the level of effort was acceptable.

Facility 19 based their performance evaluation on a sample size of 13 blanket washes and printed with soy-oil based inks. This facility considered the performance of the wash to be fair/poor. Again, the wash cut the ink well. However, it did not soak into the rag. In addition, the wash left an oily residue, which required extra effort to remove.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 34 instead of the baseline; average costs per wash increased roughly 50 percent and 80 percent at facilities 1 and 19, respectively. Performance data indicate that costs associated with product use (i.e., volume x price) at facility 1 increased roughly 160 percent. This increase is completely attributable to the alternative product's higher price. Blanket Wash 34 is priced at \$15/gallon compared to a price of \$5.88/gallon for the baseline. At facility 19, increased cleaning time is the single largest contributor to the higher average cost per wash of Blanket Wash 34; cleaning times averaged 67 seconds for Blanket Wash 31, compared to 41 seconds for the baseline product.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
1	\$0.89	\$3.56	\$8,900	\$5,900	+51
19	\$0.95	\$3.80	\$9,500	\$5,300	+79

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 34. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for terpenes and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity. Risks for petroleum distillate hydrocarbons could not be quantified. Structure-activity analysis indicates low to moderate hazard concern for these chemicals.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate hazard concern.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 35*Composition:*

Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic

VOC Content: 99%; 6.7 lbs/gal
Flashpoint: 105°F
pH: 6.0

Performance

Wipability: wet ink- 3 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 5 strokes 5 hrs.- 6.1%

The performance of Blanket Wash 35 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 35 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Moderate risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 36*Composition:*

Fatty acid derivatives
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic
Propylene glycol ethers

VOC Content: 48%; 3.5 lbs/gal
Flashpoint: 175°F
pH: 5.7 (fluctuates wildly)

Performance

Wipability: wet ink- 4 strokes Blanket swell: 1 hr.- 0.7%
 dry ink- 5 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 36 was not demonstrated at any facilities.

Cost

Cost estimates associated with using Blanket Wash 36 were not developed.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and propylene glycol ethers. Due to negligible exposure, the fatty acid derivatives present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low due to low exposure.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 37*Composition:*

Water
Hydrocarbons, petroleum distillates
Hydrocarbons, aromatic

VOC Content: 14%; 1.0 lbs/gal
Flashpoint: 82°F
pH: 3.9

Performance

Wipability: wet ink- 5 strokes Blanket swell: 1 hr.- 3.0%
 dry ink- 8 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 37 was demonstrated at two facilities. Facility 3 based their performance evaluation on a sample size of 17 blanket washes and printed with conventional inks. This facility noted that longer drying time was required with the substitute wash than with the baseline and standard facility washes. The performance was rated as good and fair on light and medium coverages, respectively. The press operators had no problems with the substitute wash.

Facility 4 based their performance evaluation on a sample size of six blanket washes and printed with conventional inks. This facility found that the substitute wash worked well initially but caused paper breakup due to blanket tackiness. Use of the substitute wash was discontinued.

Cost

Performance data indicate a reduced financial cost when using Blanket Wash 37 instead of the baseline. Average costs per wash decreased roughly 13 percent and 7 percent at facilities 3 and 4, respectively. Overall costs per wash decreased due to reduced cleaning time and material use (i.e., press wipes). Compared to the baseline, cleaning times decreased roughly 20 percent at both facilities 3 and 4.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
3	\$0.48	\$1.92	\$4,800	\$5,500	+13
4	\$0.79	\$3.16	\$7,900	\$8,500	-7

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 37. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate possible concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The petroleum distillate hydrocarbons present low to moderate hazard concern based on structure-activity analysis.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Inhalation Exposure: Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate hazard.

Flammability: High risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

Blanket Wash Formulation 38*Composition:*

Hydrocarbons, petroleum distillates
 Alkoxylated alcohols
 Fatty acid derivatives

VOC Content: 65%; 4.9 lbs/gal
 Flashpoint: 230+°F
 pH: 5.6

Performance

Wipability: wet ink- 9 strokes Blanket swell: 1 hr.- 0.0%
 dry ink- 16 strokes 5 hrs.- 1.5%

The performance of Blanket Wash 38 was demonstrated at two facilities. Facility 2 based their performance evaluation on a sample size of nine blanket washes and printed with conventional and vegetable-based inks. This facility found that the wash left an oily residue, which caused print quality problems. Use of the substitute wash was discontinued due to poor performance and print quality problems.

Facility 4 based their performance evaluation on a sample size of six blanket washes and printed with conventional inks. This facility found that the wash cut ink satisfactorily. However, use of the substitute wash was discontinued due to print quality problems associated with the oily residue.

Cost

Performance data indicate an increased financial cost when using Blanket Wash 38 instead of the baseline. Average costs per wash increased roughly 100 percent at facility 2 and 30 percent at facility 4. Costs associated with product use (i.e., volume x price) contributed significantly to the higher overall costs of using Blanket Wash 38. Specifically, compared to the baseline, costs associated with blanket wash use increased 400 percent at facility 2 and roughly 260 percent at facility 4 due primarily to Blanket Wash 38's high price. Blanket Wash 38 is priced at \$19.00/gallon compared to \$5.88/gallon for the baseline.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
2	\$1.08	\$4.32	\$10,800	\$5,300	+104
4	\$1.11	\$4.44	\$11,100	\$8,500	+31

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 38. A "+" indicates an increase in cost, and a "-" indicates a decrease.

Risk and Exposure

Dermal Exposure: Risks for this formulation could not be quantified due to the unavailability of hazard values. The fatty acid derivatives and alkoxyated alcohols are expected to present low risk based on structure-activity predictions of poor absorption and low or low to moderate toxicity. Petroleum distillate hydrocarbons present low to moderate hazard concern based on structure-activity analysis.

Inhalation Exposure: Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low due to low exposure and structure-activity predictions of low to moderate toxicity.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

None of the chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Blanket Wash Formulation 39*Composition:*

Water
 Hydrocarbons, petroleum distillates
 Propylene glycol ethers
 Alkanolamines
 Ethylene glycol ethers

VOC Content: 37%; 2.9 lbs/gal

Flashpoint: 155°F

pH: 9.2

Performance

Wipability: wet ink- 7 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 10 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 39 was demonstrated at two facilities. Facility 5 based their performance evaluation on a sample size of 32 blanket washes and printed with conventional inks. This facility found that the wash cut ink well and rated its performance as good overall. However, the substitute wash did not dry as quickly as the baseline wash and left an oily residue on the blanket. In addition, the product did not work well on rollers.

Facility 8 based their performance evaluation on a sample size of five blanket washes and printed with conventional inks. This facility noted that the wash did not cut ink well and, thus, required extra time and effort to clean the blankets. In addition, it was difficult to get the wash to soak into rags, and the wash left an oily residue on the blanket.

Cost

The results of the performance demonstration indicate an increased financial cost when using Blanket Wash 39 instead of the baseline. Costs at facilities 5 and 8 increased roughly 25 percent and 45 percent respectively when using Blanket Wash 39 instead of the baseline. Performance results indicated roughly a 40 percent increase in cleaning time at both facilities 5 and 8. Despite a 30 percent decrease in the average quantity of blanket wash used, the costs associated with product use (i.e., volume x price) did not vary between Blanket Wash 39 and the baseline. The manufacturer's price for product 39 is \$12.35/gallon compared to \$5.88/gallon for the baseline product.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
5	\$0.69	\$2.76	\$6,900	\$5,500	+25
8	\$0.80	\$3.20	\$8,000	\$5,500	+45

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 39. A "+" indicates an increase in cost, and a "-" indicates a decrease.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons, propylene glycol ethers, and alkanolamines as well as possible concern for other propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based on an inhalation study.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, propylene glycol ethers, and ethylene glycol ethers. However, the hazard value used for propylene glycol ethers is based on an oral study. Due to negligible exposure, alkanolamines present no concern.

Flammability: Low risk

Environmental: No measured risk

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Alkanolamines		X	X	X		X
Ethylene glycol ethers		X		X		

Blanket Wash Formulation 40*Composition:*

Hydrocarbons, aromatic
 Hydrocarbons, petroleum distillates
 Fatty acid derivatives
 Ethoxylated nonylphenol

VOC Content: 52%; 3.8 lbs/gal
 Flashpoint: 155°F
 pH: 4.8

Performance

Wipability: wet ink- 5 strokes Blanket swell: 1 hr.- 1.5%
 dry ink- 10 strokes 5 hrs.- 3.0%

The performance of Blanket Wash 40 was demonstrated at two facilities. Facility 1 based their performance evaluation on a sample size of six blanket washes and printed with vegetable-based inks. This facility considered the performance of the wash to be good. The facility noted that when the wash was diluted with water, it left a residue. There was no residue when the wash was used full strength.

Facility 10 based their performance evaluation on a sample size of 20 blanket washes and printed with conventional inks. This facility found that the wash cut ink well and rated its performance good. The facility noted that the wash required slightly more effort when coverage was heavy.

Cost

Performance data indicate mixed results in the performance of Blanket Wash 40. Compared to the baseline, average costs increased roughly 35 percent at facility 1 but decreased 4 percent at facility 10. The higher cost experienced by facility 1 is attributable to Blanket Wash 40's higher price as well as an increase in the average number of press wipes used. The average quantity of blanket wash used by facility 1 is 2.5 ounces for both the alternative as well as the baseline; however, costs associated with blanket wash use (i.e., volume x price) increased roughly 80 percent due to Blanket Wash 40's higher price. The reduced costs experienced by facility 10 are attributable to a reduction in the average quantity of blanket wash used. Costs associated with product use decreased roughly 30 percent for facility 10.

Facility #	Cost/Wash	Cost/Press	Annual Cost *	Baseline Cost *	% Change **
1	\$0.79	\$3.16	\$7,900	\$5,900	+34
10	\$0.87	\$3.48	\$8,700	\$9,100	-4

* These costs refer to the cost/press/shift/year

** Refers to the percent increase or decrease in cost that this facility would incur if it switched from using VM&P naphtha to using Blanket Wash 40. A "+" indicates an increase in cost, and a "-" indicates a decrease.

CHAPTER 7: EVALUATING TRADE-OFF ISSUES

Risk and Exposure

Dermal Exposure: Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for ethoxylated nonylphenol. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons due to the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Inhalation Exposure: Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Due to negligible exposure, fatty acid derivatives and ethoxylated nonylphenol present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low due to low exposure.

Flammability: Low risk

Environmental: Aquatic species risk due to the presence of ethoxylated nonylphenols.

Regulatory Concerns

The following table indicates which chemical categories present in this blanket wash contain chemicals that may trigger specific federal environmental regulation.

Chemical	CWA	CAA	CERCLA	SARA 313	RCRA	OSHA
Hydrocarbons, aromatic	X	X	X	X	X	X

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